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PLANTS AND PLANT CULTURE[1]

The enthusiasm resultant from the successful establishment of Botanical Abstracts by the combined efforts of all Americans interested in plants and plant culture has tended to revitalize the belief that a closer union of all scientific societies concerned with plants is a desideratum of great importance. In this connection the solidarity of chemistry and the consistent efforts of chemists to ally their science with industry is contrasted with the very different state of affairs that exists in botany. Another new influence of unifying tendency is the National Research Council, which, rather defying tradition, has combined in one division all of biology and agriculture. Besides it is attempting to bring about greater cooperation of research institutions and to amplify scientific activities by securing support from commercial and other sources. There still exist men who earnestly decry the economic tendencies of science and consider such argument, either as justification or for support, to be futile or dangerous. Whatever appeal there may be to botany and correlative sciences in the phrase "research for research's sake," it is Quixotic to expect it to be effective in such fields of effort as medicine, engineering and agriculture, where the relations to health, industry and prosperity are obvious.

If there is to be adopted a broader view of plant science, one that is to embrace all of conventional botany as well as plant culture, it is manifestly important that there be full discussion of the desirability of such amalgation as well as of the causes that have led to the existing state of affairs. There is apparently need of considerable readjustment of

[1] Address in the joint program of the American Society of Agronomy, Botanical Society of America and American Phytopathological Society, Chicago, December 30, 1920.

mental attitudes if the influences that have been so potent in the past are to be made nugatory.

It so happens that during the past decade or so there have been many discourses published, mostly in SCIENCE, on the general theme "What is the matter with botany?" The diverse viewpoints of experienced men have been set forth in detail, so that it is relatively easy to grasp their attitudes toward the problem. So far as I know these essays have called forth little in the way of comment from plant culturists either as expressions of sympathy or as opinions that might help in the diagnosis of the case. Now the whole matter has again come to the front, even to the extent of definite ideas to organize a broad American Plant Society that will embrace in its membership all concerned with plants or their culture. It would seem therefore that agronomists and other plant culturists can scarcely refrain longer from presenting their viewpoints as to the nature of the centrifugal forces that have kept botany and plant culture apart. Inasmuch as many botanists have attempted to define what agriculture is and what it is not, is high time that there be a rejoinder, lest silence on the part of agronomists and horticulturists be construed as assent to the statements that have been made.

A survey of the many articles by botanists in relation to the existing conditions shows that one or another of them has recognized several of the tendencies that have been more or less potent. Not unnaturally some of these tendencies or factors will be evaluated by the plant culturist quite differently from the botanist. The factors that are adduced are in part historical or traditional; in part the concomitant of intellectual isolation; and to some extent the result of conventional or even cramped ideas concerning the definition of the word science and of such phrases as pure science and applied science. Historically the development of plant culture has been almost without contact with botany or the study of plants as plants. The beginnings of plant culture go far back in the history of man, long before there were historians to record the facts or scientists to ponder over their significance. Witness the extraordinary development of maize, beans, tobacco, and other plants by the American Indian, so great indeed that the wild originals are no longer known or at least recognized as such; the marvelous series of varieties or sorghums originated by the African negroes; the endless forms of rice brought into existence by the Indo-Malayan peoples; the high development of wheat and other small grains in prehistoric times. Primitive man was indeed a wizard, agriculturally considered. Not only did he discover each and every important food plant, as well as all narcotics and stimulants, but most of them he cultivated and by one means or another developed numerous varieties. From prehistoric man we inherit not alone a wealth of crop varieties but more or less definite knowledge of cultural methods. From this foundation modern plant culture has been developed by farmers, gardeners, agronomists and horticulturists by an almost infinite amount of "cut and try." Practically all of the progress in tillage, manuring, drainage, irrigation, breeding, pruning, has thus been obtained.

It may be that underlying the historical relations or lack of relations between botany and plant culture is what one botanist refers to as "intellectual isolation," "provincialism," and as a "feeling of superiority." Perhaps the wit's definition of a professor of botany carries the same import as does the phrase "intellectual isolation." "A professor of botany is a man who teaches what he knows about plants to young men and women who expect to instruct students who desire to become professors of botany to train others to teach." This definition suggests what the doctors call a vicious circle rather than the society ideal called a "select circle."

Inasmuch as a prominent botanist used all of the quoted expressions, it may be permissible to divulge an open secret among agronomists and horticulturists, namely, that the last one especially, the "feeling of superiority," has long been recognized as an important element in preventing more cordial

relations between conventional botanists and plant culturists. In the recent articles that I have referred to, several of the writers contrast such subjects as agronomy, horticulture, forestry, with botany, manifestly implying that the former are no part of botany. The omission of the mention of any branch of plant culture in other articles would also justify the deduction that they are excluded subjects. On the other hand a few botanical writers point out that it is the great weakness of conventional botany that it has held aloof from the culture of plants as a proper field of its activity; deplore the fact that botany has been restricted mainly to impractical considerations and that the practical uses of plants have largely been segregated in other fields of endeavor. Curiously enough, botany has always displayed a more cordial attitude toward pharmacy and forestry than it has towards horticulture or agronomy. Perhaps drugs and trees smack less of the farm than do soils, manures, and crops. It may be related to that curious human tendency, especially of the city dweller, to expend wit on the tiller of the soil; a peculiar mental trait that has given a sinister or derogatory meaning to such originally innocent terms as villain, heathen and pagan.

Whatever the causes may have been, it has come about that botanists get a very different training from agronomists and horticulturists. It is a trite saying that botanists know nothing about plant culture and agronomists and horticulturists little about botany. Individuals fairly proficient in both are all too scarce. We are thus perpetuating in our schools the schism that exists between the two groups of men who devote their energies to problems concerning plants. It is comforting to believe that more and more of us are coming to realize that this is truly deplorable. I can well appreciate a consuming interest in plants solely on account of the wonderous diversity of their forms: of the extremely interesting phenomena in their growth and movements; of their complex relations to each other and to their physical environment; of the intricacies of their cellular structures and functions; but the practical world is more interested in plants as sources of food, raiment and other necessities. While it is perfectly true that mankind can not live by bread alone, it is equally true that if he does not provide for bread he will very soon be freed from all other cares and desires.

This separation of botany from plant culture is, as already pointed out, tacitly admitted in numerous recent articles. It is likewise evident enough in text-books. In Pfeffer's "Physiology of Plants," for example, whenever the subject-matter impinges on plant culture, the student is referred to Mayer or some other agricultural text. It is related of a famous German botanist that when a student asked the name of a particular cultivated plant, he replied: "How should I know? Ask the gardener." Perhaps some of the inexcusable misidentifications of plants in recent technical articles were due to asking the gardener. Some exceptions to this narrow attitude conspicuous on account of their rarity do indeed occur among botanists where men were interested in the relation of their discoveries to plant culture. I refer to such men as Gaertner, Sachs, Miller, Don, as a few examples.

Again, there are some current ideas concerning the nature of science and its conventional divisions, pure science and applied science, that need to be dispelled and if possible corrected.

Some of my botanical friends would at once protest at the title of my address, and suggest that it would better be "Plant science and plant culture," arguing in this wise: plant science or botany is the whole knowledge of plants that has been accumulated and is systematized and formulated in respect to all the general principles that have been discovered; whereas plant culture is purely an art, to a large extent the result of the application of botanical principles. As printed evidence I quote from one of the botanical writers:

Agriculture, for example, is not a science, but an art, and whatever of science it employs is ap-

plied from botany, zoology, geology, climatology and so forth.

The implication conveyed in designating plant culture as an art is presumably that a science is something intellectually higher. Of course, this is a mere matter of definition of terms. Someone has proposed the definition: Science is "finding out and learning how and why." So broadminded a man as Huxley once gave his views of science as follows:

> To my mind, whatever doctrine professes to be the result of the application of the accepted rules of inductive and deductive logic to its subject-matter: and which accepts, within the limits which it sets itself, the supremacy of reason, is science.

There is in this definition no trace of restriction as to what the subject-matter may be. It pertains quite as much to plant culture as to plant morphology, to goats as well as sheep. A restricted definition that classifies knowledge of plants as science and disposes of knowledge of plant culture as non-science, has not been a solidifying influence among plant workers.

The attempts to divide science on the basis of quality or usefulness have been in the main very unfortunate as in most cases one of the subsidiary terms involves a disparagement; thus pure science and applied (by implication impure) science; fundamental and superficial; practical and theoretical (by suggestion impractical) science; philosophical and practical science. Some of the terms suggest that they were invented by snobbish persons, but others seem sincere efforts to distinguish purely pragmatic knowledge from that which rests on a philosophical or theoretical basis. It would make for greater solidarity, I imagine, if instead of making distinctions that concern persons as well as things, we should emphasize "science in the service of humanity" or "science the handmaid of progress."

If we must persist in the attempt to distinguish two sorts of science I would suggest empirical and philosophical. The former would include in the main information based purely on observation or on test, as long as the underlying causes are unknown or vague, and which some writers delight to call "mere empiricism"; the latter to the knowledge which is illuminated by proven theory or broad inductive generalizations. I suspect it is the mental satisfaction derived from knowing something of the why and the how that tends to make us regard philosophical science as something more to be esteemed than is information of facts regarding the underlying causes of which we are either entirely in the dark or guess at vaguely. It is much as though we praised ourselves unduly when we solved wholly or in part one of nature's puzzles, and called the other fellow stupid because he could not unfold his problem. It is perhaps well to be modest and to realize that some riddles are much more difficult than others.

But the phrases "pure science" and "applied science" have involved other unfortunate consequences even to the confusion of thought. "Applied science" is conceived by some writers to imply the employment of definite known scientific truths or principles. In the words of one writer, "You must have your science before you can apply it." If this statement be true, there is very little of applied science in plant culture, or indeed in all agriculture. It is safe to say that 90 per cent. of what is known of practical methods in the culture of plants is almost purely empirical, and has been gained by an enormous amount of observation in actual trials. This information is nevertheless real knowledge as measured by the best of standards; it works in practise, however little we may know about the underlying causes or factors. The repeated assertions to the effect that the major part of agriculture is something applied from botany, chemistry, geology and what not is one that I wish emphatically to contradict. I have no hesitancy in stating that 90 per cent. of the garnered knowledge of botany in the traditional sense has no obvious relation to plant culture, and most of it has little conceivable relation. Another writer asserts,

> It is the pure or fundamental science that keeps applied science alive, that makes progress possible.

An obvious rejoinder is that is is the applied science that keeps the investigator alive. So far as plant culture is concerned, it existed thousands of years before there were such a thing as pure or fundamental science, unless I mistake what is meant by this phrase. Clearly the quotation asserts too much, if plant culture is part of "applied science."

The statement that plant culture is made up largely of botany is objectionable, first of all because it is offensively patronizing and second because it is to a great extent not true. The plant culturist, be he agronomist, horticulturist, forester, or what not, is concerned first of all in the methods that make for the successful culture of a plant, and secondarily in the factors or factor complexes that affect quantity or quality of yield. Yield, including the underlying factors, is the central consideration in plant culture, but the word yield is seldom seen in a botanical text-book. In the culture of crops there are four major series of factors that affect yield, namely, the adaptations of the plant, the quality of the soil, the climatic factors, the cultural or artificial factors. It is a fair assumption that if the best adapted variety be planted on rich soil and intelligently cultivated the highest yields are to be expected if the weather condition are favorable and pest injury reduced to a minimum. It is worth while considering briefly just how much we know concerning the relation of yield to a few of the factor complexes mentioned.

Consider first the plant and its habits, or if you prefer its ecological adaptations. Undoubtedly primitive man, like the modern grower of orchids, attempted when he first cultivated a plant to imitate its natural habitat. He certainly did not plant rice on the dry hilltops nor wheat in the marshes. But what after all do we know about these habital adaptations save by observation. No sensible man would expect to succeed with bananas outdoors in New England. But just why is it, if you please, that bananas can not stand as much cold as apple trees? Or consider a simpler case, namely winter wheat and spring wheat, perhaps representing the broadest extremes in a single species of physiological adaptation in relation to temperature that has been developed in plant culture. Just why does the one endure much lower temperatures than the other? It would seem practically certain that the differences are not due to any morphological character, since similar phenomena occur in naked organisms; therefore, it is nearly certain the differences in adaptation lie in the protoplasm. But it must be admitted we have not even a working hypothesis as to the nature of the machinery.

Again consider the behavior of some introduced plants with that of others brought from the same region. Bluegrass, redtop and white clover have spread over all of the northeastern fourth of the United States and tend quickly to occupy all cleared and untilled land; in other words, they spread aggressively. In contrast, certain other common European grasses can barely exist or do not thrive at all. Crested dog's-tail is rather a botanical rarity in the United States notwithstanding that thousands of pounds of seed are sown annually, just because the English consider it a good grass. Still more remarkable is *Weingartneria canescens,* a grass the viable seed of which is an abundant impurity in certain European seeds, but no one has ever found a specimen of the plant in the United States. Japan clover, introduced accidentally about 1853, has spread over all the south. The lowland ranges of California are covered with grasses and other herbs, 80 per cent. of the bulk of which is made up of Mediterranean plants. On the foothills of the Himalayas the Mexican dahlia escaped cultivation and now covers miles of the mountain sides. In Ceylon and Java an extremely aggressive and abundant sunflower-like plant is *Tithonia diversifolia,* which in its native home near Acapulco, Mexico, is a very restricted rather rare plant. Many other cases might be cited. Why are some of these introduced plants so aggressive and others so impotent? It is an evident fact and a clear problem of much importance agriculturally. All that we can postulate is that as a rule an introduced plant that is aggressive comes from a region

with closely similar climatic conditions. Rarely a native plant shows similar aggressiveness like ragweed in the north and *Eupatorium capillifolium* in the south. Various hypotheses have been advanced to explain the aggressiveness of weeds, but they are simply hypotheses. Certainly attempts to find a correlation between weediness and abundance of seeds produced has proved a dismal failure. Nor has any better success been achieved toward understanding the contrasting phenomenon of dwindling or "petering-out."

The distribution of the species of a genus —let us say the oaks of the United States—is an interesting phenomenon. But why is one species circumscribed thus and another delimited so? To say the species have different adaptations is merely stating the fact in other words. If we are honest, we must admit, I think, our complete ignorance. Now these are samples of a great group of phenomena that confront students of cultivated plants. They must very properly, I think, also be considered problems of ecological botany. But the ecology of the botanists has not thus far developed enough to be an asset to the plant culturist. The details of pond margins, mountain tops, and seashore strand throw no light on why maize or potatoes or wheat thrive better in some situations than in others.

Now we come to soils. Surely chemical and botanical science have here rendered signal service to plant culture. Here again it is well to consider primitive plant culture. Undoubtedly our prehistoric ancestors must have observed the greater luxuriance of plants on certain soils, about dung droppings and on landslides. Certain it is that long ago many uncultured tribes had learned to use dung, ashes, fish, leaf mold, seaweeds, and other substances to increase yields. One of the early results achieved by chemists and botanists was to determine the chemical elements necessary to plant life. Eventually from this developed the idea that all of these necessary elements were amply abundant everywhere except nitrogen, phosphorus and potash. And very naturally substances containing these elements were sought out to use as fertilizers. The history of the development leading up to the conclusion stated and its general adoption, was by no means simple. On the agricultural side the great exponent was Liebig. But one can not to-day read Liebig's numerous works without realizing how much he floundered in the maze of conflicting facts and theories and the many errors into which he was led. In his combatting of the old humus theory of plant nutrition he denied any value whatever to humus except to supply carbon dioxide, but in spite of his teachings the German farmers refused to abandon the use of dung and compost. Liebig also clung to the idea that nitrogen was of no avail as a fertilizer, as the atmosphere furnished abundant supply. One of the controversies over nitrogen was finally solved by Helriegel and Wilfarth, who established the fact that legumes by the aid of root nodules were able to utilize atmospheric nitrogen. This is one of the striking landmarks of agricultural science, but it is well to remember that the practical effect of legumes in rotation was well known to the Romans and other ancient peoples. In Hartes "Husbandry," published in 1764, is written:

All plants that bear leguminous flowers (as lucerne, sacrifoin, trefoils, vetches, etc.) enrich the ground and of this the husbandman has daily experience in the culture of clover.

In its final evolution the Liebig theory of soil fertility came to mean that the productivity of a soil was primarily determined by the quantity and availability of the nitrogen, phosphorus and potash which it contained. Indeed many modern writers identified these three substances as *fertility*.

Curiously enough, almost any experienced farmer will express an opinion after examination as to the quality of a soil. His standards of measurements are about as follows: Soils decrease in productivity based on correlation with texture in about this sequence—clay loams, loams, silt loams, clays, fine sands, coarse sands, gravel; and in color in about this order—black, brown, red, yellow, gray, white. His judgment is therefore based in part on texture and in part on color. Crude

as this basis of measurement may be, it certainly has some correlation with productivity. Indeed it may be said that chemical methods of soil examination resulted in a great neglect of the study of the more obvious characteristics. Unquestionably the best index of the quality of a soil is its productivity in crops. Analyses of soil from good spots and from poor spots in the same field have sometimes revealed no differences. This fact and others led to the concept that productivity might be lessened not only by the absence of a necessary element but the presence of a deleterious agent, and that fertilizers were in some cases at least substances that inhabited the injurious factor. It is a long story to consider this subject, but viewed purely as a theory it can explain some things not clarified by the plant food theory. It is well to remember that many investigators who considered the effects of nitrogen, phosphorus and potash as due solely to additional plant food, nevertheless regarded the effects of lime as partly at least due to overcoming an unfavorable factor, and the action of still other materials as stimulants, without clearly defining what they meant by stimulants. The available facts were simply the addition of the substance and the end reaction of the plant. The different rôles postulated are in the main hypotheses, and the existing body of facts certainly is insufficient to prove any one of the simple theories. A broader view now coming to be widely held is that the soil is a complex of very numerous factors, good, bad, or indifferent so far as a particular plant is concerned, and the end result measured in yield is the balance of the conflicting factors. To state it in another way productivity is probably quite as much influenced by qualitative soil differences as by quantitative diversities—but the theory that has generally been accepted is purely quantitative. Such a view of "soil fertility" which it must be admitted can now be measured only in terms of yield, means that it is comparable in scope to "weather" as applied to the seasonal complex of climatic factors. The actual knowledge that we have of soil productivity and of fertilizers is therefore still almost wholly empirical. The extension and clarification of this knowledge is, it seems, most likely to be obtained by a much more intimate knowledge of the plant reactions to each of the soil factors that can be controlled and the different combinations of these factors. An exceedingly interesting recent contribution is that of Bottomley, who presents strong experimental evidence to show that highly organized green plants must have dead organic matter as part of their food.

The effects of one crop upon another often very marked, sometimes beneficial, more often injurious. The nature of these effects is very obscure, but it now seems clear that it can not be wholly related to the quantitative supply of plant food. These phenomena have been used to lend support to the theory that yields are often greatly reduced by the presence of deleterious substances, in this case supposed to be excreted by the preceding crop. The theory is attractive in its simplicity and there is some evidence in its favor, but there is no clear proof that plants do excrete repellant substances. The curious way in which certain wild plants occupy areas to the complete or nearly complete exclusion of other species might well be due to such a factor. The effect of one plant upon another is an old observation in plant culture, and appears in botanical literature as early as Von Mohl. It is only in recent years that the actuality of the fact is established beyond doubt. An understanding of its basic causes is manifestly a matter of great importance. At the Rhode Island Experiment Stations, onions varied in yield from 13 bushels to 412 bushels per acre in a long series of plots, the differences being due solely to the effects of the preceding crops.

The subject of tillage is likewise one much involved. The simplest plant culture requires some disturbance of the soil, even if only to remove stones or roots. But different methods or different degrees of stirring the soil, show marked effects on subsequent yields. So great are these differences that the famous Jethro Tull proclaimed the slogan "Tillage is

manure," meaning that the same end results could thus be obtained. Why? There is a bewildering array of hypotheses as to why tillage tends to increase yields, including better mechanical conditions; improved aeration; increased nitrification; additional carbon dioxide; mixing of the soil; elimination of weeds; and in dry regions particularly conservation of moisture. There may be and probably is some truth in all of these explanations but exact data on any of them are far from abundant. The really definite knowledge is empirical, namely, that tillage methods do tend to increase yields.

The breeding of plants has been a most potent factor in securing larger and better yields. Our knowledge of genetic phenomena has been enormously increased in recent years from the activity incited by the rediscovery of Mendel's law. The effect of this greatly increased knowledge of genetics has inspired many immoderate statements as to its effect on agriculture. Thus one writer says "Through scientific work in the study of heredity, we have learned to multiply the races of our useful plants so that they may fit in more exactly to the variable conditions in which plants must be grown," and that Mendel's law "is the basis of most of our work in the study of heredity and this in turn has made agriculture scientific." It is pleasing to learn that a bit of leaven like this is able to uplift all agriculture into the condition called scientific, while presumably it was before something different. As a matter of fact, the practical value of Mendelian knowledge to plant breeding is disappointingly small. Witness the innumerable improved varieties in all our cultivated plants long antedating Mendel. Consider the lilies, the roses, the chrysanthemums, the carnations, the tulips, indeed, any plant much cultivated, and ponder upon the infinite amount of work that led to their development—all without the guidance of any scientific theory. This admission does not discount the tremendous value of the new knowledge of genetics which gives us so great an insight into the factors involved in plant variations.

The nature of plant diseases and the methods discovered for their control is a contribution to plant culture for which the botanists of the schools may rightly claim large credit. This is clear in spite of the fact that farmers and gardeners had before the day of plant pathologists found out the efficacy of bluestone for wheat smut and sulphur for mildew; and against other diseases had developed resistant or immune varieties. The development of phytopathology is an index, I believe, of what might well happen in other fields of plant culture, if trained botanical workers will wholeheartedly engage in its problems and avoid being attracted more to the purely scientific problems than to those of cultural import.

The climatic complex of factors is difficult to evaluate. Numerous attempts have been made to correlate growth and yield with the curves of temperature and of moisture precipitation and even specifically to outline the limits of the future extension of wheat culture northward. Thus far these attempts have not thrown any great light on the problems of climatic adaptations.

I must not omit, however, the recent illuminating contribution of Garner and Allard, who have discovered the remarkable reactions of plants to the length of daily illumination. Any one who has cultivated plants has come to realize the extraordinary way in which they behave under different conditions, one might say the vagaries which they exhibit. One of these is the manner in which most plants speed up their maturing in fall. The farmer says the plant is hurrying to get ripe before frost. Several vague theories were current among plant culturists as to the cause of this phenomenon, one that the stimulating factor was the increasing difference between day and night temperatures, another that it was due to the increased temperature of the soil. It is remarkable to how high a degree the temperature factor was assumed in every periodic phenomenon. Garner and Allard have accumulated a mass of experimental data that leave no room for doubt that the stimulating factor is associated with the daily length of

illumination. Indeed it may be hazarded that it is this stimulus which normally controls all recurrent periodic phenomena in plants and animals. Just how it is to be correlated with certain other phenomena which form the basis of Kleb's salts-carbohydrate theory is not yet clear. It is quite possible that entirely different stimuli affect the control of vegetative and reproductive phenomena so as to give similar end reactions. The Garner-Allard factor certainly provides a new method of approach to study the internal factors that control the plant's activities. It is probably not a wild guess that these internal factors are as numerous as the genetic factors concerned in the plant's heredity mechanism. As it happens, the approach to this problem and the progress made in its solution was purely from the agronomic viewpoint and with the object of solving an agronomic puzzle. This is worthy of mention as an illustration of the fact that the plant culturist gets a different contract with plant phenomena from the botanist of the laboratory.

The plant culturist has long been familiar with the phenomena illuminated by Garner and Allard. It is this factor which in the case of field crops led to date of seeding trials —by which in a purely empirical way the best date of seeding or planting for each locality was determined. Any one who has seen plots of millet, for example, planted at succeeding dates will appreciate how much this factor alone can affect yields.

Another important factor affecting yield is the spacing of the plants whether secured by rate of seeding or by planting at measured distances. It is easy to understand why too sparse seeding will reduce yields and also to comprehend that crowding may result unfavorably—but it is doubtful if any other method than actual trials will ever enable us to ascertain the optimum rate of spacing for any particular crop at any specific place. Curiously enough as Mooers has shown, varieties of maize not markedly unlike have very different optima as regards spacing. In southern India where rice culture is very ancient, and the seedlings are transplanted by hand, Wood was able to increase yields materially by determining the optimum spacing distance. Incidentally this greatly reduced the amount of seed necessary which in a country where the daily wage is eight cents was a considerable economic factor. Such empirical data as these are highly important in plant culture—and it seems not unlikely that they always will have to be determined by test and not by some mathematical equation.

In America, crops are mostly planted as pure culture, in India usually as mixed cultures, one of the plants commonly a legume. Mixed cultures usually outyield pure cultures —but except where the crops are garnered by hand, the increased cost of harvesting becomes an important economic factor. Why mixed cultures, even of the small grains, outyield pure cultures is an interesting phenomenon, and one can easily theorize to his heart's content. In nature plants are usually, but not always, in mixed cultures. Actually we know practically nothing of these phenomena except the observed or experimental facts.

Perhaps no one will contend that a graduate of the best botanical courses in America is thereby fitted to undertake the cultivation of any crop, let alone such as require special knowledge and skill. It is remarkable to how great a degree that success in growing a crop is based on the slowly accumulated results of experience. During the war you will remember there was urgent need for a large supply of castor beans. It is doubtful if in the whole history of American agriculture there was ever a more dismal failure than the attempt to produce these beans. There was an abundance of theoretical data based on the culture in other countries, but in attempting to grow the crop in the United States the handicaps of unadapted varieties and unexpected difficulties proved disastrous. Perhaps in no other industry is the advice "Make haste slowly" more applicable than in agriculture.

I have endeavored to point out by a few examples of plant cultural problems how different they are from those considered in the conventional botany of the schools. The

methods of research developed in the laboratories hardly apply at all to the problems of plant culturist, a fact that the laboratory men have scarcely appreciated, and which has led them into a mental attitude disparaging toward the methods of the agronomist and horticulturist. It is not insignificant that the discoveries of Mendel, of Helriegel and Wilfarth. of Garner and Allard were made possible by problems revealed in the culture of plants and all were solved by the simplest of methods. Koelreuter's work in hybridization was largely inspired by his knowledge of garden plants, and was promptly utilized by horticulturists though ignored by botanists. One may well doubt whether laboratory botanists could ever have detected the meaning of the dance of the chromosomes; though I am not unaware that there were dim guesses as to what they might signify even before the revelations of modern Mendelism.

One of the phrases too often seen in print is "revolution in agriculture." The expression is almost purely rhetorical and not a statement of fact or even of approximation. In most cases large changes in agriculture have been due to very simple things, usually the introduction of a new crop or the sudden expansion of an old one. Witness alfalfa in the west, sorghums in the southwest, rubber in Malaya, the sugar beet in Europe, the increase of cotton in the south following the invention of the cotton gin. I can recall nothing of comparable effect on agriculture resultant from a discovery in a botanical laboratory. It may be argued, truly enough, that the knowledge of bacteria has revolutionized modern medicine; but the credit for this advance can scarcely be claimed by botanists. Botany seems truly to have neglected its splendid opportunities in its adherence to the fetich of pure science.

It may be well to caution that in any attempt to unify botany and plant culture, the word botany will exercise no hypnotic influence. Rightly or wrongly the word does not convey to the public mind something highly desirable and useful. To the ordinary man a botanist is a more or less queer individual who goes about with a tin box over his shoulder collecting plants. Perhaps this had something to do with the loss of caste of taxonomy among botanists. It may be questioned, however, if the whittling of paraffine sections, or the use of strange apparatus in the woods and marshes, or the growing of fungi in test tubes will lead to a profoundly different evaluation of botany.

I trust that any frankness of expression that I have indulged in will not be interpreted as ill-will, but that it will be regarded as an effort to clear away the mist and to bring about better understanding. Much that has been written on the general subject seems to carry the impression that plant culturists have a stolidity that partakes of the ox, and do not wince at the reflections that come from the pens of botanists. It may be well to dispel any such assumption, which in my judgment has done incalculable harm to botany.

The points of my thesis are virtually three: (1) that our knowledge of plant culture is to a very large extent still almost purely empirical; (2) that there has been a lamentable tendency to consider plant culture and its methods of study as something apart from botany and not worthy of so high respect; and (3) that there has been proneness to claim for botany as well as for chemistry an undue amount of merit for what they have contributed to agriculture.

I have, I believe, as much faith as any one in the services that plant science can render to mankind, and that not by furnishing bread alone. There is need, however, of broadening our vision and ideals, of freeing ourselves from any caste feeling, of recognizing that the human race is at least as much interested in food and food production as it is in the fate of the synergids, the origin of the angiosperms, or the genes of *Capsella*. For the good of all of us there is every reason to bring about a closer union of the societies interested in plants and their culture. Such a union will without doubt lead to better mutual understanding and reciprocal sympathy. At least we shall learn that most conventional botanists as well as plant culturists are, after all, to

use the expressive slang of the day, "regular fellows."

The last few years have taught us all how small a reserve of food there is even in normal times. Largely as a result of the cataclysmic war famine now stalks over much of the earth. It needs no Malthus to convince us that an adequate food supply will become more and more the great problem of mankind. In spite of the haziness that envelops most of our present theories of productivity, one can scarcely fail to have faith that it is the half light that precedes dawn. The complex and obscure factors involved in crop production need for their solution a far greater number of botanically trained investigators. With clearer theoretical understanding of these factors, there is every reason to believe that the earth will be made to yield more abundantly. It is to this field of investigation so vital to human welfare, that I confidently hope botanists will more and more devote their energies, both as a matter of duty to mankind, and as an earnest of faith in their science and the services it can render.

CHARLES V. PIPER

SCIENTIFIC EVENTS

THE CARNEGIE TRUST FOR SCOTTISH UNIVERSITIES

THE *British Medical Journal* states that the annual meeting of the Carnegie Trust for the Universities of Scotland was held in a committee-room of the House of Lords, on February 9, with Lord Balfour of Burleigh in the chair. Lord Balfour said that the principal event of last year was the allocation of grants for the quinquennial period of 1920–25. In addition to the £200,000 from income, it had been resolved to allocate from the reserve fund £49,000. The explanation of this was that during the war the students at the universities were fewer, and therefore the trustees saved on the payment of fees. It would have been absurd to save that money and put it to the reserve, when many of the same students were coming back after the war and wanted it. The trustees thought it right, as a temporary measure, to take it out of the reserve fund, and give it to them to pay their fees. Under the research scheme it had been agreed that as an experiment for a period of three years the following annual grants be offered to the universities to be spent in payment of half the salaries of persons engaged as part-time assistants or lecturers on condition that they devoted not less than half their time to research, and that the universities should contribute the other half of the salaries from other sources—Glasgow and Edinburgh £1,000 each, St. Andrews and Aberdeen £800 each. It was hoped that much good to the universities would result from this combination of teaching and research, and the scheme had been well received by the universities. Although the amount available for assistance to students was now fully £60,000, there was a deficit of £8,538 for 1919–20. The universities were now increasing their tuition fees, and as a result the poor student would be poorer than ever. Thus the difficulties were very great. For many years the trustees had been able to pay all eligible applicants the whole of their class fees, but in 1911–12 they had had to have an allowance system, because the income would not cover the whole of the fee, and since then the trustees had been paying only a part of the fees. The situation would be further changed in the current year owing to the increase in tuition fees.

The discussion in which Lord Haldane, Lord Sands, and others took part, centered chiefly in the problem of allocating assistance to the students. It was agreed that steps must be taken to eliminate from the beneficiaries of the fund those applicants whose circumstances were such as to render assistance unnecessary. Proposals were made for strengthening the declaration made by applicants and for an inquiry into individual circumstances. The suggestions were discussed, but a decision will not be reached until the alternatives have been further considered in the light of the views expressed by university authorities and others interested.

MEETING OF THE ORGANIZING COMMITTEES OF THE SECTIONS OF THE BRITISH ASSOCIATION

Nature states that a combined meeting of organizing committees of the Sections of the British Association was held at Burlington House, on February 25. The meeting was called to consider various suggestions as to number and grouping of sections, presidential addresses, and other subjects discussed in the recent correspondence in *Nature* and elsewhere, and also to facilitate the arrangement of joint programs between two or more sections for the annual assembly at Edinburgh in September next. At the general session it was agreed that the number of sections should not be reduced, but that voluntary grouping for the consideration of subjects of common interest was desirable. The council (through the general officers) was empowered to fix hours of addresses and discussions, and the view was approved that the oral delivery of presidential addresses should be optional, as well as that the addresses themselves might be used to open discussions. It was also decided that the council should invite the recorders of sections, or their nominees, to be present at meetings of council when presidents of sections are elected. Organizing committees will thus, through their representatives, be able to put forward their views as to new sectional presidents. Several joint discussions were arranged for the forthcoming Edinburgh meeting, among them being one between the Sections of Physics and Chemistry on Dr. Langmuir's theory of the atom, and another between the Sections of Economics, Education, and Psychology on vocational education and psychological tests.

THE PERSONNEL RESEARCH FEDERATION

Under the auspices of the National Research Council and the Engineering Foundation, in the building of the National Research Council, Washington, the organization of the Personnel Research Federation was effected on March 15. This federation includes in its membership scientific, engineering, labor, management and educational bodies. It has been organized to bring about interchange of research information among the organizations which are engaged in personal research. It is reported to the new federation by the Bureau of Labor Statistics that there are 250 such organizations in the United States. The Personnel Research Federation will collect research information, will encourage research through individuals and organizations and will coordinate research activities.

Temporary officers were elected as follows:

Chairman: Robert M. Yerkes, representing the National Research Council.

Vice-chairman: Samuel Gompers, representing the American Federation of Labor.

Treasurer: Robert W. Bruere, representing the Bureau of Industrial Research.

Secretary: Alfred D. Flinn, representing the Engineering Foundation.

Acting Director: Beardsley Ruml, assistant to the president of Carnegie Corporaton of New York.

The aims of the new organization are increased efficiency of all the personnel elements of industry—employer, manager, worker—and improved safety, health, comfort and relationships.

The immediate purposes of the Personnel Research Federation will be to learn what organizations are studying one or more problems relating to personnel and the scope of their endeavors, and to determine whether these endeavors can be harmonized, duplication minimized, neglected phases of the problems considered and advanced work undertaken.

On November 12, 1920, a preliminary conference was held in Washington under the auspices of the National Research Council and the Engineering Foundation, attended by forty persons, including representatives of national organizations of scientists, engineers, labor, capital, managers, educators, economists and sociologists. The question under discussion was the practicability of bringing about cooperation among the many bodies conducting research relating to men and women in industry and commerce, from management to unskilled labor. Such topics as the relations of persons doing different parts of the

work, and the influence of working conditions upon the health, output and happiness of the workers, are examples of those which could be made subjects of research. The underlying ideas which led to the conference, were (1) the advantages of studying such questions by the scientific method of gathering facts and using them to reach conclusions instead of discussing opinions and propaganda, and (2) the need for cooperation among the organizations and individuals engaged in such studies.

GRANTS FOR RESEARCH MADE BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AT the Chicago meeting of the association, the Committee on Grants distributed five thousand dollars for the year 1921 in different sciences as follows:

MATHEMATICS

One hundred and fifty dollars to Professor Solomon Lefschetz, of Kansas University, in support of his work in algebraic geometry.

PHYSICS

One hundred and fifty dollars to Professor W. F. G. Swann, of the University of Minnesota, for the investigation of atmospheric electric phenomena in the upper air.

Two hundred and fifty dollars to Professor H. M. Randall, of the University of Michigan, in support of his work on the infra-red rotational absorption spectra of gases.

Two hundred dollars to Professor Walter G. Cady, Wesleyan University, Middletown, Connecticut, in support of his work on electrical reactions produced by piezo-electric crystals in high frequency circuits, and the internal viscosity of elastic solids.

One hundred dollars to Professor Paul F. Gaehr, of Wells College, for his study on the specific heat of tungsten at incandescent temperatures.

One hundred dollars to Professor Arthur L. Foley, of Indiana University, in continuation of a previous grant for his experiments on the speed of sound close to the source.

CHEMISTRY

Two hundred dollars to Dr. Gerald L. Wendt, University of Chicago, for investigations at high temperatures.

Two hundred dollars to Professor Graham Edgar, of the University of Virginia, for the purchase of a quartz mercury arc lamp for research in photo-chemistry.

ASTRONOMY

Two hundred dollars to Dr. Sebastian Albrecht, of Dudley Observatory, Albany, New York, in support of his investigation of the variation of wave-length of lines in different types of stellar spectra.

Two hundred dollars to Miss Caroline E. Furness, Vassar College Observatory, for assistance in the measurement and reduction of photographic plates.

GEOLOGY

Three hundred dollars to Mr. Frank B. Taylor, Fort Wayne, Indiana, as a second grant in support of his field studies on the stages of the last glacier as it retreated down the St. Lawrence Valley.

Two hundred dollars to the Seismological Society of America, to replenish the fund at their disposal for the immediate investigation of earthquakes by sending a competent observer to the place of occurrence before much of the evidence has been obliterated.

ZOOLOGY

Two hundred dollars to Dr. P. W. Whiting, of St. Stephens College, in addition to previous grants in support of his study of genetics in insects.

Four hundred and fifty dollars to Dr. N. A. Cobb, of the United States Department of Agriculture, for aid in a series of researches into the physiology of the cell; also to defray cost of publication of results already on hand.

BOTANY

Three hundred dollars to Professor George B. Rigg, of the University of Washington, for work on the sphagnum bogs of the Puget Sound region.

Five hundred dollars to Professor J. M. Greenman, Missouri Botanical Garden, toward the completion of his work on the Senecio and related genera.

PSYCHOLOGY

One hundred and fifty dollars to Professor T. R. Garth, of the University of Texas, for a psychological study of Indiana children in the United States Indian Schools at Chilocco, Oklahoma, and Albuquerque, New Mexico.

One hundred and fifty dollars to Professor E. G. Boring, Clark University, for the preparation of

a set of steel acoustic cylinders to be used in determining the nature of sensory response under conditions of normal psychometric situation.

ANTHROPOLOGY

Two hundred dollars to Professor A. L. Kroeber, of the University of California, for bibliographical and clerical assistance in connection with an ethnological investigation to determine the culture areas of aboriginal South America.

One hundred and fifty dollars to Miss Helen H. Roberts, of the American Museum of Natural History, for a study of negro folk-music in Jamaica.

PHYSIOLOGY AND MEDICINE

One hundred and fifty dollars to Professor Carl J. Wiggers, Western Reserve University, in continued support of his investigation on the physiology of the circulation.

One hundred and fifty dollars to Professor Frank A. Hartman, University of Buffalo, for aid in the study of suprarenal insufficiency, including circulatory, respiratory, temperature, and fatigue changes, as well as possible histological alterations in the ductless glands.

Two hundred dollars to Professor W. E. Garrey, Tulane University, for the purchase of apparatus for hydrogen ion determination.

One hundred and fifty dollars to Professor F. P. Knowlton, Syracuse University, in support of a study of the blood flow and gaseous metabolism in the thyroid gland.

JOEL STEBBINS,
Secretary Committee on Grants
URBANA, ILLINOIS

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM CROCKER, associate professor of botany in the University of Chicago, has been appointed director of the newly founded Thompson Institute for Plant Research at Yonkers, New York. He will enter on his work next autumn. The board of trustees of the new foundation will consist of three business men and three scientific men. Professor John M. Coulter, head of the department of botany at the University of Chicago, and Raymond F. Bacon, of the Mellon Institute of Pittsburgh, will be two of the scientific men, and these two will select the third.

THE nomination made by ex-President Wilson, not confirmed by the Senate before adjournment, of Rear-Admiral E. R. Stitt to the position of Surgeon-General of the Navy, succeeding Rear-Admiral Braisted, retired, has been sent again to the Senate by President Harding.

HONORARY membership in the Chemists' Club of New York City was conferred upon four American and four foreign chemists at the dinner commemorating the tenth anniversary of the opening of its present home at 52 East Forty-first Street. The foreign chemists were Dr. Giacomo Giamician, professor of general chemistry at the University of Bologna, Italy; Dr. Henri Louis Le Chatelier, professor at the Collège de France and at L'École des Mines; Dr. Ernest Solvay, of Brussels, Belgium, founder of the ammonia-soda process, and Sir Edward Thorpe, professor of chemistry emeritus of the Imperial College of Science and Technology, South Kensington, England. The Americans were Dr. John Uri Lloyd, of Cincinnati, former president of the American Pharmaceutical Association; Dr. William Henry Nichols, of New York, former president of the American Chemical Society, the Society of Chemical Industry and the Eighth International Congress of Applied Chemistry; Dr. Edgar Fahs Smith, of Philadelphia, President of the American Chemical Society and until recently provost of the University of Pennsylvania, and Dr. Edward Weston of Newark, N. J.

DR. FRANK WIGGLESWORTH CLARK and Dr. H. S. Washington have been elected foreign members of the Geological Society of London.

THE following fifteen candidates have been selected by the council of the Royal Society to be recommended for election into the society: Dr. W. E. Agar, Dr. F. W. Aston, Professor W. L. Bragg, Dr. W. T. Calman, Dr. A. Church, Professor G. Dreyer, Professor W. H. Eccles, Dr. J. C. G. Ledingham, Mr. C. S. Middlemiss, Professor K. J. P. Orton, Dr. J. H. Parsons, Professor J. C. Philip, Dr. A. A. Robb, Sir E. Tennyson D' Eyncourt, and Mr. G. Udny Yule.

THE council of the Chemical Society has awarded the Longstaff medal to Professor J. F.

Thorpe. The presentation was made at the annual general meeting on March 17.

LIEUTENANT EUGENE F. DU BOIS has been given the Navy cross "for distinguished service in the line of his profession while attached to the *U. S. Submarine N-5* upon the occasion of a collision between that vessel and the *Charles Whittemore*.

PROFESSOR A. A. MICHELSON, head of the department of physics at the University of Chicago, has been appointed exchange professor at the University of Paris. His course of lectures will be on the general subject of "Physics" and will be given in the French language. The sixth Guthrie lecture in connection with the Physical Society of London, was delivered on March 11 by Professor Michelson, whose subject was "Some recent applications of interference methods."

THE Rumford Committee of the American Academy of Arts and Sciences has recently made the following appropriations: To Professor P. W. Bridgman, of Harvard University, $400 in aid of his research on the thermal and optical properties of bodies under high pressure; to Professor Paul F. Gaehr, of Wells College, $250 in aid of his research on the specific heat of tungsten.

THE Carnegie Institution of Washington has appropriated $750 for the support of the work of Dr. S. J. Holmes, professor of zoology in the University of California, on the factors of evolution in man.

MR. EDWIN KIRK, who resigned from the U. S. Geological Survey in April, 1920, to do private work in South America, has been reinstated as geologist with the Survey.

PROFESSOR EDWARD KREMERS has returned to active service in the University of Wisconsin, after a semester's leave of absence spent largely on historical studies.

PROFESSOR E. W. D. HOLWAY, of the University of Minnesota, and Mrs. Holway, have returned from a year's exploration of the western slopes of the Andes in search of plant rusts. They went southward about as far as the island of Chiloé and northward to Quito, a range of forty degrees of latitude. Over a thousand numbers were secured, in most part supplemented by phanerogamic specimens of the hosts. The collection is notable for its large proportion of grass rusts.

DR. F. GOWLAND HOPKINS, professor of biochemistry at the University of Cambridge, will deliver the ninth Harvey Society lecture at the New York Academy of Medicine on Saturday evening, April 2. His subject will be "The chemical dynamics of muscle." Sir Walter Fletcher, secretary of the Medical Research Committee of Great Britain, will deliver a Harvey lecture on April 16.

THE following Mayo Foundation lectures have recently been delivered: President Ray Lyman Wilbur, of Leland Stanford University, "Botulism"; Dr. J. Whitridge Williams, professor of obstetrics in and dean of Johns Hopkins Medical School, "A critical review of twenty-one years' experience with Cesarean section"; Dr. G. Carl Huber, professor of anatomy, University of Michigan, "Experimental observations on bridging nerve defects."

DR. EDWARD C. FRANKLIN, professor of organic chemistry at Stanford University, will give a series of three lectures on the "Ammonia system of acid bases and salts," at the University of Wisconsin, on May 2 and 3.

A COURSE of twelve lectures on petroleum geology and the engineering phases of petroleum development was delivered during March at Harvard University by Frederick G. Clapp. Mr. Clapp also lectured before the Geological Conference in Cambridge, on "A geologist's trip through China."

DR. CHARLES A. SHULL, head of the department of botany of the University of Kentucky, has received an invitation from Dr. E. J. Russell, director of the Rothamsted Experimental Station at Harpenden, England, to present a paper on "Osmotic Phenomena" as related to soil moisture, before the Faraday Society at its next annual meeting at London in May. The meeting of the Faraday Society will be devoted this year to a symposium and general discussion on "Physico-chemical Problems relating to the Soil." The subject

will be presented in four sections, Soil Moisture, Organic Matter, Adsorption and Colloidal Phenomena; the general discussion being opened by Dr. Russell.

Dr. Frank W. Gunsaulus, since 1892 president of the Armour Institute of Technology, died in Chicago on March 17, aged sixty-five years.

The death is announced of Louis Compton Miall, F.R.S., till 1907 professor of biology at the University of Leeds, at the age of seventy-nine years.

Emile Bourquelot, professor of pharmacy in the University of Paris, has died at the age of sixty-eight years.

The fourteenth annual meeting of the Illinois State Academy of Science will be held at the Southern Illinois State Normal University, Carbondale, on April 29 and 30. Papers will be presented in the following subjects: (1) Biology and Agriculture; (2) Chemistry and Physics; (3) Geology and Geography; (4) Mathematics and Astronomy; (5) Medicine and Public Health; (6) Psychology and Education. The address of the retiring president will be "The Illinois Ozarks," and invitation addresses will be given on subjects concerned with southern Illinois. The afternoon and evening programs will be of a popular character and complimentary to the citizens of Carbondale.

The American Association of Pathologists and Bacteriologists, the American Society for Cancer Research, the American Society of Immunologists and the International Association of Medical Museums (American and Canadian Sections) will meet in Cleveland from March 24 to 26.

The American Engineering Council has joined with the National Association of Manufacturers, the American Patent Law Association, the American Chemical Society and the National Research Council in a movement to bring about reforms in the United States Patent Office. Conditions in the office, according to a statement issued by the council, are such as to menace seriously American industry and invention. A committee on patents has been appointed by the executive board of the council to prosecute a nation-wide campaign for the betterment of the patent office situation. This committee, as announced by President Hoover, is headed by Edwin J. Prindle, of New York, who represents the American Society of Mechanical Engineers on the council. The other members of the committee are J. Parke Channing, of New York, secretary, representing the American Institute of Mining and Metallurgical Engineers; Charles A. Terry, of New York, vice-president of the Westinghouse Electric and Manufacturing Company, representing the American Institute of Electrical Engineers; C. A. P. Turner, Minneapolis, American Society of Civil Engineers; Corydon T. Purdy, New York engineer, and Horace V. Winchell, mining geologist of Minneapolis, American Institute of Mining and Metallurgical Engineers; Dr. D. S. Jacobus, vice-president of Willcox & Babcock Company, American Society of Mechanical Engineers, and Frank H. Waterman, electrical expert of New York City, American Institute of Electrical Engineers.

The Lord President of the Council of Great Britain has appointed an Interdepartmental Committee on Patents to consider the methods of dealing with inventions made by workers aided or maintained from public funds, whether such workers be engaged as research workers or in some other technical capacity. The committee is to outline a scheme to give a fair reward to the inventor, and thus encourage further effort while protecting the national interest. Among the members of the committee are Dr. H. H. Dale, F.R.S., head of the department of biochemistry and pharmacology of the Medical Research Council.

At the Springfield meeting of the Association of Land-grant Colleges officers were elected as follows: *President,* H. L. Russell, of Wisconsin; *Vice-president,* Howard Edwards, of Rhode Island; *Secretary-treasurer,* J. L. Hills, of Vermont; and members of the executive committee, R. A. Pearson, of Iowa, chairman; W. M. Riggs, of South Carolina, W. E. Stone, of Indiana, A. R. Mann, of New

York, and F. B. Mumford, of Missouri. For the various sections the officers are as follows: Agriculture, Dean Mumford, chairman; W. F. Handschin, of Illinois, vice chairman, and W. H. Chandler, of New York, secretary; engineering, C. R. Richards, of Illinois, chairman, and R. L. Sackett, of Pennsylvania, secretary; and home economics, Edna L. Skinner, of Massachusetts, chairman, and Mildred Wiegley of Minnesota, secretary. For the three subsections of the section of agriculture, R. L. Watts, of Pennsylvania and C. D. Jarvis, of the U. S. Bureau of Education were chosen chairman and secretary, respectively, in resident teaching; F. S. Harris, of Utah and T. P. Cooper, of Kentucky, chairman and secretary in experiment station work; and H. J. Baker, of Connecticut and J. A. Wilson, of Oklahoma in extension work.

UNDER the auspices of the American Ophthalmological Society, the Ophthalmic Section of the American Medical Association, and the Academy of Ophthalmology and Oto-Laryngology, an International Congress of Ophthalmology will be held in Washington, D. C., April 18–22, 1922. The officers of the temporary organization are as follows: *President,* Dr. George E. de Schweinitz, Philadelphia; *Vice-president,* Dr. Edward Jackson, Denver; *Secretary* and *Treasurer,* Dr. Luther C. Peter, Philadelphia; *Chairman of Committee on Organization,* Dr. Edward C. Ellett, Memphis, Tenn.; *on Scientific Progress,* Dr. Edward Jackson, Denver; *on Finances,* Dr. Lee M. Francis, Buffalo; *on Arrangements,* Dr. William H. Wilmer, Washington, D. C., and *on Membership and Credentials,* Dr. Walter R. Parker, Detroit.

THE *Experiment Station Record* reports that plans are under way for a laboratory building for chemical, bacteriological and other research work of the Netherlands Institute of Animal Nutrition, and it is hoped to complete the structure in about two years. An annex to the laboratory is being built for immediate occupancy. This is a one-story structure about 117 by 62 ft., with basement and attic, and will be known as the vitamin laboratory. The main floor contains several offices and laboratories, but consists largely of quarters for mice, rats, monkeys, rabbits, fowls and guinea pigs. Special facilities are to be provided for keeping many of the animals in open warrens during the day, for disinfecting cages, and otherwise maintaining the best of hygienic conditions. The library is on the attic floor where considerable storage space is also available.

THE Association of British Chemical Manufacturers, as reported in the *British Medical Journal,* is circulating a memorandum on the present position of the fine chemical industry. The facts and arguments are on similar lines to those in the pamphlet issued from the Society of Chemical Industry. It is stated that British chemists, as a result of the stimulus imparted by the war, have brought the manufacture of the chemicals used in research and in photography, and of certain synthetic perfumes and essences, to the verge of commercial success, while the manufacture of drugs has made immense strides, and would have made greater had not the Order in Council prohibiting the importation of drugs been set aside by the Sankey judgment. The hope is expressed that the Key Industries Bill, which has been promised as a government measure of the new session, may do for fine chemicals what has already been done for dyestuffs by the act recently passed; that is to say, that some protection may be granted to the manufacturers of fine chemicals until they have consolidated a position which has been hardly won and which is still precarious. The insecurity arises from the fact that there are circumstances, including the great priority of organization, and also the present state of the exchanges, which favor the German laboratories. The national importance of this industry in peace and war is pointed out, and it is also stated that, excluding coal-mining, the fine chemical industry yields the highest net value of output per person employed.

As a result of the recommendations of the Wisconsin Chapter of the American Engineering Society, a bill has been introduced in the Legislature of Wisconsin providing for the registration of engineers, chemists, metallur-

gists and land surveyors. The proposed act calls for the registration of all members of these professions who practise their profession in the state of Wisconsin. It is understood, however, that only those persons whose practise of their profession involves the public health and safety will be affected by this law. In order to receive a certificate of registration an engineer or chemist must present evidence that he is fully qualified to practise his profession, and that he is of good character and repute, that he is at least twenty-five years of age and that he is a citizen of either the United States or Canada. The following—under the provisions of the proposed act—will be considered as evidence of the professional qualifications: 1. Ten or more years of active engagement in the profession. 2. Graduation, after a course of not less than four years, in chemistry, from a reputable college, and an additional four years of active engagement in the profession. The act provides for a board to apply the provisions of the act, for penalties in case of presentation of fraudulent evidence to obtain a certificate, and for penalties for those who practise fraud or deception in the practise of their profession.

UNIVERSITY AND EDUCATIONAL NEWS

By the will of Daniel Baugh a legacy of $150,000 has been left to the Jefferson Medical College of Philadelphia, to be used for the salary of the professor of anatomy and director of the Daniel Baugh Institute of Anatomy and Biology. J. Parsons Schaeffer, M.D., Ph.D., is the present occupant of these positions. Mr. Baugh was a trustee of the Jefferson Medical College and made generous gifts to it, including an institute of anatomy.

The graduate school of Yale University has been authorized to confer the degree of doctor of philosophy for work in clinical medicine, and in pharmacology and toxicology.

The University of Alabama, cooperating with the U. S. Interdepartmental Social Hygiene Board, has established a department of hygiene, with Dr. Hiram Byrd as director.

Dr. Eliot Blackwelder, of Denver, Colo., formerly associate professor of geology in the University of Wisconsin, has been appointed lecturer on geology at Harvard University.

Dr. E. W. Scripture, formerly of Yale University and the medical school of Columbia University, has been appointed to the faculty of the University of Hamburg for the summer semester, where he will lecture on English philology and experimental phonetics.

DISCUSSION AND CORRESPONDENCE

THE PREGLACIAL OUTLET OF LAKE ERIE

Two or three months ago an item went the rounds of the newspapers to the effect that in digging for the locks on the new Welland Canal, at Thorold, ten or twelve miles west of Niagara Falls, the workmen had uncovered evidence of the existence there of the long-looked-for preglacial outlet from Lake Erie into Lake Ontario. Partly for the sake of verifying this, I chose to spend my vacation at St. Catharines, two or three miles north of Thorold. Thorold is on the brink of the escarpment of Niagara limestone overlooking the Ontario basin and 330 feet above the surface of the lake. St. Catharines is at the base of the escarpment, nearly down to the level of the lake. At Thorold, as well as at various other places along the escarpment, there is a slight incision made by a small stream which poured over the escarpment in preglacial times. But it does not extend far. What was shown in the excavation for the Welland Canal was simply the edge of the escarpment where it had been rounded off by glacial action without lowering it to any extent. It is interesting and important to note that the movement of ice was here from north to south, almost at right angles to the escarpment. The workmen reported that at a low level just north of the escarpment a great quantity of bowlders was found, which would seem to be something of the nature of a moraine. As the ice met and overcame the edge of the escarpment it was occasionally deflected into a minor incision, but after it mounted the escarpment a long level sur-

face rock was exposed with beautiful parallel striation running north and south. The exposure, therefore, had nothing to do with the preglacial outlet, but it gave emphatic evidence that the ice movement was not in the direction of the axis of the lakes but directly across it, and hence could not be a means of eroding the lake basin.

The actual preglacial outlet of Lake Erie, however, emerges from the escarpment about three miles southwest of St. Catharines. This was discovered by Dr. J. W. Spencer and the evidence presented in great detail in his report published by the Canadian Survey in 1907, on "The Evolution of the Falls of Niagara," a volume of 500 pages in which the facts relating to Niagara Falls and the glacial phenomena of the peninsula between the lakes are presented with great fullness and accuracy. I could do little more than follow in Dr. Spencer's footsteps with this book in hand, to test the evidence. The results of Spencer's investigations are very impressive as one goes over the field. At the point mentioned there is an embayment in the escarpment, two miles wide at the level of the Niagara limestone; and lower down at the level of the Clinton limestone or Medina sandstone, the gorge is a mile wide filled with glacial debris which has been penetrated by wells to a considerable distance below the level of Lake Ontario. The glacial filling in the gorge, which originally rose to the surface, has been much eroded by Twelve Mile Creek and its tributaries which penetrate it, giving rise to a region known as the "short hills."

Three or four miles above the mouth of the gorge the line of the outlet is covered by a remarkable deposit of superficial glacial debris known as Font Hill which is something like an immense drumlin or kame and rises at its sumit 300 feet above the level of the Niagara escarpment and extends in a northeast-southwest direction between three and four miles, being at its widest point about a mile wide. The material shows stratification on the sides, such as appears in eskers. This accumulation is unique, and rises up like a mountain peak out of the level plain which extends all the way north to the Lake Erie basin. I will say nothing further about the theory of its origin at present; but will reserve what I have to say upon it for some future occasion when I may consider it in connection with some other unique glacial accumulations of that character in that region, notably, Berrymans Hill, about a mile west of Niagara Falls.

North of Font Hill, as has been said, there extends a level plain to Lake Erie and only fifteen or twenty feet above it. In this plain all preglacial channels are obliterated by the glacial deposits which form the surface; but Dr. Spencer had collected the record of wells all over the region, which show clearly that there is a continuous buried channel, about 200 feet deep, which emerges from Lake Erie just east of Lowbanks, about half way between the mouth of Grand River and the head of the Welland Canal at Port Colborne. There is, therefore, no doubt left that this "Erigan channel," as Dr. Spencer calls it, which emerges from the Niagara escarpment near St. Catharines is the real preglacial outlet to Lake Erie.

Dr. Spencer's investigations concerning the tributaries of this Erigan channel are also of special interest, and it was the facts, revealed by the well borings, concerning these that led to the real discovery. Chippewa River, which enters the Niagara just above the falls, rises twelve or fifteen miles west of the Erigan channel; but before it reaches the Niagara it crosses a buried channel which well borings show slopes from the Niagara River southwestward until it merges into the Erigan channel. Numerous other tributaries are found to do the same. Mr. Spencer's investigations deserve to be more widely disseminated to forestall the publishing of such items as that referred to at the beginning of this communication.

G. FREDERICK WRIGHT

OBERLIN,

RELATIVITY AND ESTIMATES OF STAR DIAMETERS

TO THE EDITOR OF SCIENCE: In reducing the measurements of the diameter of Betelgeuse

made with Michaelson's wonderful apparatus, no allowance appears to have been made for the effect of the gravitational bending of light. Obviously this would make the apparent angular diameter greater than the real, and a rough approximation shows that this gravitational effect may be of the same or an even larger order of magnitude than the observed angle.

Knowing the parallax and being able to make an approximate estimate of the density, the true diameter of Betelgeuse may be determined with fair accuracy. I have made a rough calculation and find that it is approximately only one fifth of the diameter given, but the calculation should be made by others better fitted than I am.

Reginald A. Fessenden

THE CONSERVATION OF GAME AND FUR-BEARING ANIMALS

The New York State Conservation Commission issues *The Conservationist.* Among the many important communications in it, I wish to call especial attention to one, "New York's annual game dividend," written by Warwick S. Carpenter, secretary of the Conservation Commission.

On the basis of precise data the conclusion is reached that the game and fur-bearing animals of New York state, if capitalized, are worth not less than $53,000,000; they return an annual dividend of more than $3,200,000; and they cost the state for their protection and increase the nominal sum of $182,000. This cost of protection and increase is thus less than six per cent. of the annual dividend.

There is need for emphasizing the financial as well as the æsthetic and scientific sides of the conservation problem and these findings of Mr. Carpenter deserve wide publicity.

Henry B. Ward

SCIENTIFIC BOOKS

A Laboratory Manual of Anthropometry. By Harris H. Wilder, Ph.D., Professor of Zoology, Smith College, Northampton, Mass. 200 pp., 43 illus., P. Blakiston's Son and Co., Phila., 1920.

In order that the records of each observer may be readily made use of by every other observer, it is imperative that series of measures be uniform and be taken in uniform ways. The matter of unification was first placed upon an international basis by the International Congress of Anthropologists held at Monaco in 1906. The unification process was carried still further at the Geneva Congress in 1912. There remain for consideration at some future Congress the general skeletal measures, exclusive of the cranium and lower jaw.

The work of the special International Commissions rightly forms the basis of Wilder's Laboratory Manual. However his statement on page vi of the Preface, that the periodicals in which the reports of the labors of the two Commissions "appeared were exclusively European," is incorrect; for a report from the reviewer's pen, of the work accomplished at Geneva, translated from the official copy of Dr. Rivet, chief recorder of the Commission, appeared both in Science[1] and in the *American Anthropologist* for the year 1912.

To the measures accepted by international agreement, the author adds a convenient and useful list of general skeletal measures, as well as angles and indices. No mention is made of the Sphenomaxillary angle, which might well find a place even in an abridged manual. His enumeration of instruments and description of the manner in which they are employed are done with a thorough knowledge of the difficulties which beset the beginner. The pages devoted to simple biometric methods were written for the special benefit of the student, whose chief interest is in morphological relations, and whose mathematical ability and training are not sufficient to enable him to follow abstruse biometric methods.

To the laboratory student of the subject, Wilder's Manual is recommended for its lucidity and conciseness, as well as for the author's ability to transmit a maximum amount of his own pervading enthusiasm for the subject by means of the printed page.

[1] Vol. XXXVI., 603-608, November 1, 1912.

For good measure, two instructive appendices are added: *A*. Measures of Skulls of 93 Indians from Southern New England; *B*. Bodily Measures of 100 Female College Students.

GEORGE GRANT MACCURDY
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THE PRODUCTION OF BIOLOGICAL STAINS IN AMERICA

BACTERIOLOGISTS, during the war time, were often hindered in important work, sometimes involving matters of health control, by the lack of dyes which they were accustomed to use for staining. Some laboratories were provided with a sufficient supply of Grübler stains to use all through the war and are only now running out of this supply; but others were early forced to buy stains of American manufacture. Some of the American stains were so poor as to be unhesitatingly condemned, others although enough for some purposes were not suitable for the particular objects of bacteriologists, while others were so variable as to be unreliable.

Now that the war is over, biological scientists and their supply houses are faced with the problem whether to urge the importation again of German stains (which can now be done only with special permit) or to encourage the establishment of an American source of supply. As scientists we have no objection to the use of German-made materials, and if no other solution of the problem can be found we will be willing enough to consider the Grübler stains standard again, as soon as they can be freely obtained. From the standpoint of national independence, however, it seems well first to see what American producers can do for us in this line, especially when it is considered that certain stains are important to public health and that we ought to be able to count on an uninterrupted supply if there should ever be a new national emergency when importation would become impossible.

The Committee on Bacteriological Technic was asked by the Society of American Bacteriologists to look up the matter, to see whether reliable stains can be obtained in this country and further to see what can be done to protect bacteriologists against the unsatisfactory stains that are put upon the market. Upon looking into the situation we find that all the bacteriological dyes, and nearly the whole list of biological anilins are produced in America in reliable form. The chief difficulty is that there are too many competitors in the field for such a small line of business. Grübler apparently examined all the available textile dyes and determined which were useful to biologists, standardizing them so that the stains bearing his name were uniform. Then he sold them at a high percentage profit, but a perfectly legitimate profit, considering the labor he saved biologists by the study he gave the subject. A number of American concerns, attracted by the great difference between the cost of crude dyes and the price of biological stains, have thought to realize quite a profit from the business, and have begun the "manufacture and standardization" of biological dyes—often to their own discomfiture, but always to the discomfiture of the users of the stains. For a while there was success for all, because a scientist would give any firm a single test; but the result was a needless duplication of dyes of the same name, sometimes alike, but often different, and also the introduction of new names for old dyes. Although some of these concerns are now going out of business, the confusion still remains.

Gradually the users, or at least the distributors, have been learning which houses are manufacturing the most satisfactory stains, and the less reliable manufacturers have been forced out of the business. But the present situation is such that the future importation of German stains is no longer regarded as impossible. Fearing competition from abroad as well as from the unreliable concerns at home, some of the best producers of biological stains are becoming discouraged and are abandoning the effort to increase their line. Under these circumstances the only way to assure the continued domestic

production of stains is through the cooperation of scientists. After determining some one reliable line of stains we should make this line standard as the Grübler stains were once, and discourage the entrance of new manufacturers into this rather limited field. The line selected as standard need not be all the output of any one laboratory; but the production of *any one stain* in several different laboratories is an unnecessary waste of effort. All the distributors of stains are anxious to avoid this sort of duplication, and whenever one has been approached in the matter, most hearty cooperation has been assured us.

To carry out this program means considerable preliminary work to determine which of the domestic sources of each stain is the most reliable. Although we have considerable light on this subject already, and can in many cases make private suggestions of possible value to purchasers, we have not as yet the data necessary for making any official statement. We are now planning a series of tests of the most important bacteriological dyes in a considerable number of different laboratories, the outcome of which may determine our future action in the matter. As a society of bacteriologists we are of course primarily interested in the most commonly used bacterial stains, such as fuchsin, methylen blue, the gentian violet group, and the prepared blood stains. Secondarily, however, we are interested in securing the cooperation of other biologists in an attempt to standardize eventually the whole field.

This article is being written in the hopes of securing this cooperation. We wish to invite other biologists as individuals and through their organizations to work with us in the matter. Any one interested in our purpose is urged to communicate with the committee.

H. J. Conn, *Chairman*,
Committee on Bacteriological Technic, of the Society of American Bacteriologists
Agricultural Experiment Station,
Geneva, N. Y.,
March 1, 1921

SPECIAL ARTICLES

THE STRUCTURE OF THE STATIC ATOM

In attempting recently to derive the conditions which determine the stability of chemical molecules I was impressed by the importance of the part played by Coulomb's law of inverse square forces between charged particles. In fact, by considering a static arrangement of electrons according to the models which I proposed two years ago, and calculating the total potential energy by Coulomb's law, I have found it possible not only to determine the relative stability of various substances but to calculate with reasonable accuracy the heats of formation of compounds even of widely varying types.

In all such calculations, however, it is necessary to assume that the electrons are kept from falling into the nucleus by some undetermined force, for Coulomb's law alone can not account for this. According to Bohr's theory of atomic structure, the requisite repulsive force is nothing more than centrifugal force due to rotation of the electrons about the nucleus. This theory has been so remarkably successful in accounting for the spectra of hydrogen and helium that the fundamental assumption of movement about the nucleus has seemed justified, notwithstanding the fact that this violates all our classical laws regarding the radiation of energy from accelerated electrons.

From the chemical point of view it is a matter of comparative indifference what the cause of the repulsive force is, so long as it exists. I therefore endeavored to find what law of repulsive force between electrons and positive nuclei would produce an effect equivalent to the centrifugal force of Bohr's theory.

According to Bohr the average kinetic energy in any atom or molecule is half as great as the average potential energy, but opposite in sign. I therefore now assume that this energy, which Bohr called kinetic, is another form of potential energy dependent upon certain quantum changes in the electron.

From this potential energy it is then easy to determine the law of repulsive force.

The result of this analysis is that we may regard the force between any nucleus of charge Ze and an electron of charge e as consisting of two parts which act independently. The first is the Coulomb attractive force F_c given by

$$F_c = \frac{Ze^2}{r}. \tag{1}$$

The second force, which we may call the *quantum force* is a repulsive force F_q given by

$$F_q = \frac{1}{mr^3}\left(\frac{nh}{2\pi}\right)^2. \tag{2}$$

In these equations r is the distance between the electron and the nucleus, m is the mass of the electron, h is Planck's quantum, and n is an integer denoting the quantum state of the electron. This repulsive force, varying inversely as the cube of the distance, is remarkable in that it is independent of the charge on the nucleus. It is to be noted especially that an electron which has not undergone any quantum change and for which therefore $n = 0$, follows Coulomb's law accurately. Thus presumably β-rays in passing through an atom will be acted on only by the usual law.

It can be readily shown that under the influence of these two forces an electron will be in stable equilibrium when it is at a distance from the nucleus equal to

$$a = \frac{n^2 a_0}{Z}, \tag{3}$$

where a_0 is given by

$$a_0 = \frac{h^2}{4\pi^2 me^2}. \tag{4}$$

This result is identical with that for the radius of the orbit in Bohr's theory, but of course the law of force was chosen to give just this result.

If W is the total energy of the system with its sign reversed we obtain

$$\frac{W}{W_0} = \frac{2Za_0}{r} - \frac{n^2 a_0^2}{r^2}, \tag{5}$$

where

$$W_0 = \frac{2\pi^2 me^4}{h^2}. \tag{6}$$

Equation (5) has no equivalent in Bohr's theory for it applies to the transitions between stationary states. The first term in the second member represents the Coulomb potential while the second corresponds to the quantum potential.

When an electron has settled down into its position of equilibrium, the value of W becomes

$$W = \frac{Z^2 W_0}{n^2}. \tag{7}$$

This also is identical with the result obtained by Bohr for the total energy in any stationary state. It follows from this that the Rydberg constant, the Balmer series and all other series calculated by Bohr can be obtained by this method without assuming electrons moving about the nucleus.

If the electron is disturbed from its position of equilibrium it oscillates about this position. From equation 5 the frequency of this oscillation is found to be

$$\nu = \frac{4\pi^2 Z^2 me^4}{n^3 h^3}. \tag{8}$$

This is identical with the frequency of revolution of the electron in Bohr atom. From this we may draw a definite physical picture of the mechanism of the transition between two states, at least when Z is large. Bohr has shown that under these conditions the frequency radiated when an electron passes from one circular orbit to the next inner one is the same as the frequency of revolution. According to the present theory, if the quantum number of an electron in a stable position decreases by one unit, the electron is no longer stable but falls towards its new position of equilibrium, and oscillates about this position. It then radiates its energy of oscillation according to the usual laws of electro-dynamics.

One of the greatest successes of the Bohr theory is that it accounts for certain slight differences between hydrogen and helium lines

by the nuclear mass correction. This correction is taken care of in the present theory with the same accuracy if we assume a slight modification to our law of quantum repulsion, viz. replace equation (2) by

$$F_q = \left(\frac{nh}{2\pi}\right)^2 \frac{\frac{1}{m} + \frac{1}{M}}{r^3}, \tag{9}$$

where M is the mass of the nucleus. This seems to indicate that the quantum force is due to an interaction between the electron and the nucleus in which both masses play a similar rôle. For example, it may be imagined that both are set into rotation in opposite directions about the axis connecting them.

Sommerfield has accounted for the fine-line structure of spectral lines by considering a relativity correction due to the rapid motion of the electron. This would seem to be excellent proof that the electrons do move. However, it is possible that the motion resides within the electron and nucleus. It is probably significant that the relativity correction can be taken into account in the present theory if we substitute in equation 2 in place of n^2 the expression

$$(n_a + n_r)^2 - \alpha^2 Z^2 \left(\frac{n_r}{n_a} + \frac{1}{4}\right), \tag{10}$$

where α is a constant calculated by Sommerfeld. A consideration of this equation may lead to more definite conceptions of the structure of the electron and nucleus. The quantities n_a and n_r refer to what Sommerfeld calls angular and radial quanta. It is not yet clear just what interpretation is to be placed upon these in the present theory but they are evidently only of secondary importance in determining the forces between the electrons and the nucleus.

When we consider other atoms such as helium it seems as if the new theory may lead us much further than the usual theory, for the determination of equilibrium positions under static forces is extremely simple compared to the corresponding dynamical problem. Furthermore we are not troubled by mysterious quantum conditions which are theoretically applicable only to periodic orbits while the calculated orbits in atoms are not periodic.

At present I am studying the spectra of helium and lithium from this viewpoint. The following tentative conclusions may be stated.

The quantum force between quantized electrons is not as simple as between electrons and nuclei. The quantum force between electrons on opposite sides of a nucleus is one of repulsion whose magnitude is approximately given by equation (2) if the quanta are all of the "angular" type, but is considerably less when the quanta are of the "radial" type. But if the electrons are on the same side of the nucleus, the quantum force between electrons is one of attraction, also given approximately by equation (2). Thus if one of the electrons in the helium is uniquantic, and the other one is diquantic, the latter can take equilibrium positions either on the opposite side of the nucleus from the uniquantic electron or on the same side. This perhaps explains the fact that helium (as well as other elements with two outer electrons such as calcium, etc.) has two separate complete sets of spectra (helium and parhelium). It is also in accord with the remarkable facts in regard to the helium spectrum which were recently pointed out by Franck and Reiche.

These properties of the electron are in full accord with those which are needed to account for chemical relationships. The new theory fulfills the predictions of G. N. Lewis who in 1916 wrote[1] in reference to Bohr's theory:

> Now this is not only inconsistent with the accepted laws of electromagnetics but, I may add, is logically objectionable, for that state of motion which produces no physical effect whatsoever may better be called a state of rest.

It is also in accord with the conclusion which I gave in a paper entitled "The properties of the electron as derived from the chemical properties of the elements,"[2] viz.:

[1] *Jour. Amer. Chem. Soc.*, 38, 773 (1916).
[2] *Phys. Rev.*, 8, 300 (1919).

How can these results be reconciled with Bohr's theory and with our usual conception of the electron? It is too early to answer. Bohr's stationary states and the cellular structure postulated above have many points of similarity. It seems that the electron must be regarded as a complex structure which undergoes a series of discontinuous changes while it is being bound by the nucleus or kernel of an atom. There seems to be strong evidence that an electron can exert magnetic attractions on other electrons in the atom even when not revolving about the nucleus of the atom.

IRVING LANGMUIR
RESEARCH LABORATORY,
GENERAL ELECTRIC CO.,
SCHENECTADY, N. Y.,
March 8, 1921

THE OKLAHOMA ACADEMY OF SCIENCE

THE ninth annual meeting was held in Oklahoma City on February 11, at the State University, Norman, on February 12. The following papers were read:

Presidential Address: *Research in secondary schools:* A. F. REITER.

The organization of a research council in Oklahoma: GUY Y. WILLIAMS.

On the affiliation of the Oklahoma Academy of Science with the American Association for the Advancement of Science: L. B. NICE.

The ceremonies and rites incident to eating peyote among the Cheyenne Indians: J. B. THOBURN.

The intrinsic-extrinsic mechanism of heredity and variation: H. H. LANE.

An eccentric hen—anatomically excused: A. F. REITER.

On the non-singular cubic: NATHAN ALTSCHILLER-COURT.

A survey of the taxation system of Oklahoma: F. F. BLACHLY.

The teaching efficiency of motion pictures measured in terms of results secured under schoolroom conditions: J. W. SHEPPARD.

Where did the Indians of the Great Plains get their flint? CHAS. N. GOULD.

An objective view of education in Oklahoma: MIRIAM E. OATMAN-BLACHLY.

The most important scientific spot on earth: WALT B. SAYLER.

An observation on the male Dickcissel during the nesting period: ED. CRABB.

The genetic evidence of a multiple (triple) allelomorph system in bruchus and its relation to sex-limited inheritance: J. K. BREITENBRECHER.

Some studies with complement deficient guinea pigs: H. S. MOORE.

The migration path of the germ cells in fundulus: A. RICHARDS and J. T. THOMPSON.

Nesting of mourning doves at Norman in 1920: MARGARET M. NICE.

Some notes on winter birds around Norman in 1920–21: MARGARET M. NICE.

A comparison of the rate of diffusion of certain substances, particularly the food materials, enzymes and pro-enzymes: ALMA J. NEILL.

Further observations on tonus rhythms in diaphragm muscle: L. B. NICE and A. J. NEILL.

A child's deviations from truth: SOPHIA R. ALTSCHILLER-COURT.

The range of vocabulary at eighteen months of age: MIRIAM E. OATMAN-BLACHLY.

Relation of science to art: LUCILLE CARSON.

The bank of Missouri: J. RAY CABLE.

A plan to reach the Orinoco sources: T. A. BENDRAT.

The cliff-dwellers in Mesa Verde Park, Colorado: C. W. SHANNON.

A trip across the Navajo desert: JUANITA RAMSEY.

Evidence on the Pennsylvania glaciation in the Arbuckle Mountains: S. WEIDMAN.

Toyah, Texas, oil pool: BESS MILLS.

The Marietta syncline and its effect upon the physiography of Love County: FRED BULLARD.

Deep tests in southwestern Oklahoma: WALDO PORTS.

Protozoa of Colorado: T. C. CARTER. (Read by title.)

The grand period of growth of root-hairs: R. E. JEFFS. (Read by title.)

During the session it was voted to affiliate the Oklahoma Academy of Science with the American Association for the Advancement of Science forming two classes of members, local and national.

It was also voted to establish a State Research Council in the Oklahoma Academy of Science along the same plan as the National Research Council.

It was further voted to establish a Natural History Exchange for the purpose of assistance in building museums in the colleges and high schools of the state.

The following resolutions were adopted:

1. Whereas, it is highly desirable to save the wild life in the state, the Oklahoma Academy of Science places itself on record as favoring the making of all state, municipal or other public lands and waters into game preserves.

2. Whereas, hawks and owls have been shown by the United States Biological Survey to be of far more benefit to agriculture than injury, the Oklahoma Academy of Science places itself on record against the bill now pending in the Oklahoma legislature to put a bounty on these birds.

3. Whereas, the Oklahoma Academy of Science wishes to encourage research in all branches of science, and good library facilities are absolutely necessary for such work, the Oklahoma Academy of Science places itself on record in favor of passing the bill now before the Oklahoma legislature to appropriate $50,000 to establish a State Industrial Library at the University of Oklahoma.

4. Whereas, it is to the best interest of science in the United States to have the metric system to be the standard of weights, the Oklahoma Academy of Science places itself on record in favor of the bill now pending before the United States Congress to change from our present standard of weights to the metric system.

5. Whereas, complete protection of the natural parks of the United States is essential to the happiness of the people for all generations to come, and

Whereas, the Smith bill which has recently passed the United States Senate and is now pending in the House, and also the Walsh bill, pending in the Senate, would throw open the Yellowstone National Park to predatory wealth, thus depriving the people of one of the most beautiful pleasure spots in the world, the Oklahoma Academy of Science places itself on record as being opposed to both of these bills.

The following officers were elected for the ensuing year:

President, J. B. Thoburn, Oklahoma City.
First Vice-president, Guy Y. Williams, Norman.
Second Vice-president, R. O. Whitenton, Stillwater.
Secretary, L. B. Nice, Norman.
Treasurer, H. L. Dodge, Norman.
Curator, Fred Bullard, Norman.

L. B. Nice,
Secretary

Norman, Okla.

THE WESTERN SOCIETY OF NATURALISTS—NORTHWEST SECTION

The Northwest Section of the Western Society of Naturalists met at the Oregon Agricultural College, Corvallis, Friday and Saturday, November 26 and 27, 1920. The following papers were presented at the session Friday afternoon:

Explosion of crab spermatozoa: Nathan Fasten, Oregon Agricultural College.

Some early botanists of the Northwest (illustrated): Albert R. Sweetser, University of Oregon.

A fossil cetacean from the Miocene of Newport, Oregon: E. L. Packard, University of Oregon.

Neuromotor apparatus in ciliates: H. B. Yocom, University of Oregon.

Records in eugenics: Catherine W. Beekley, University of Oregon.

Friday evening a dinner to the visiting biologists was given at Waldo Hall by the Biological Club of Oregon Agricultural College. The program following the dinner consisted of a symposium on "Biology in its relation to the development of the Northwest." The subject was discussed from the following standpoints:

Forestry: H. S. Newens, Oregon Agricultural College.

Horticulture: W. S. Brown, Oregon Agricultural College.

Zoology: Trevor Kincaid, University of Washington.

Fisheries: E. Victor Smith, University of Washington.

Fish Parasitism: Nathan Fasten, Oregon Agricultural College.

Biological Stations: Geo. B. Rigg, University of Washington.

Dr. S. M. Zeller, of Oregon Agricultural College, was elected secretary for the coming year. It was decided to hold the next meeting at the University of Washington, Seattle, during the Thanksgiving recess, 1921. The Northwest Section embraces Oregon, Washington, Idaho, Montana, Wyoming and British Columbia.

Geo. B. Rigg,
Secretary

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